which are social, not individual. Combined with these comes the growth of totemism and the recognition of emotions which we class indiscriminately as religious.

The first part of the work is devoted to an account of the customs in Melanesia, contributed by Mr. R. W. Williamson. Needless to say, this instalment is illustrated by a fine series of photographs.

The work, as a whole, if it does not make all its readers anthropologists, is admirably designed to excite popular interest in a most fascinating science.

Grundriss der Biochemie für Studierende und Aerzte. By Prof. Carl Oppenheimer. Pp. vii + 399. (Leipzig: Georg Thieme, 1912.) Price 9 marks.

THE title of Prof. Oppenheimer's book is somewhat misleading. One expects to learn something fundamental about the chemistry of living organisms, but the subject matter is mainly concerned with the chemistry of mammalian functions.

The book is divided into two sections. The first consists of a description of chemical substances. As such it comprises a synopsis of organic chemistry with references to the biological source and significance of the substances described. The second section contains a brief outline of the chemical processes concerned in mammalian physiology.

The scope of this book indicates that it is intended for medical students preparing for their examination in physiology. The compressed descriptions render the reading dull, and at the same time the amount of information is not sufficient to make the book useful for reference purposes. Bearing these points in mind there is no doubt that the author has accomplished his purpose. There is a clear, short statement concerning the chemical properties of the different compounds found in the body, a description of enzyme action, and an outline of the chemical processes concerned in the activity of the body. A knowledge of the facts described would enable a student to pass any ordinary examination in physiological chemistry. H. E. R.

Legends of our Little Brothers: Fairy Lore of Bird and Beast. By Lilian Gask. Pp. 268. (London: G. Harrap and Co., n.d.) Price 3*s.* 6*d.* net.

THESE stories, retold from the folk-lore of many lands, will inspire sympathetic interest in animal life in the young readers for whom they are written. From every point of view they are far better than the grotesque tales often supposed to be suitable for children. They tell of self-sacrifice, right relations of man to the creatures around him, the blessing of pity, the wrong of wanton killing, the suffering caused by thoughtlessness, the origin of the totem as the bond of union between men, and many like matters. We have read the stories with interest, and congratulate the author upon her rendering of them. As a gift-book the collection merits wide distribution.

LETTERS TO THE EDITOR.

[*The Editor does not hold himself responsible for opinions expressed by his correspondents. Neither can he undertake to return, or to correspond with the writers of, rejected manuscripts intended for this or any other part of* NATURE. *No notice is taken of anonymous communications.*]

The Investigation of Flint.

THE remarkable body which we know as "flint" was, in the early history of mankind in this part of the world, as important, relatively to the general conditions of life, as the metal "iron" is at the present day. In order to interpret correctly the significance of fractured flints—whether as due to man's agency or to other causes—and also in order to infer from the glaze, polish, colour, opacity, or other features of a humanly worked flint what are the geological and other physical conditions to which it has been subjected, very definite and accurate knowledge of flint, only to be arrived at by careful quantitative investigation, such as the skilled physicist and chemist can bring to bear, is necessary. Yet the entire scientific world is in a remarkable state of ignorance with regard to flint.

Flint has been neglected by the geologist, mineralogist, chemist, and physicist for reasons which are not very obvious. At the present moment there is great need for a thorough study of flint, a study which no one man can undertake and carry through. At the same time, it is possible for an individual to indicate what are the lines of investigation which seem to be those which should be followed, and I venture to make the attempt.

(1) First, as to the *history* and *nature* of "flint." By the word "flint" we understand the black-looking siliceous nodules which occur in the upper chalk of this country, and have been broken up and variously altered and re-deposited in the Tertiary and Quaternary strata. Any investigation of "flint" as thus understood must include an inquiry into the history and nature of "chert," and of those flint-like concretions which occur in both Tertiary and Mesozoic strata. The history and the structure of agate must also be compared with those of flint, since geodes of agate are not only also composed of silex, but have many properties in common with flints.

It will be further necessary to distinguish and account for the varieties of flint which are known to occur in the chalk. Thus we have in the chalk of the south of England not only nodular flints disposed in distinct beds or horizons of stratification, but we have also tabular flint formed in fissures which traverse obliquely or vertically many feet of thickness of chalk strata. We have also local varieties of chalk-flints, some darker and greener when thin splinters are examined, others yellower, and others of a bluish tendency. Others, again, are somewhat grey and opaque. Some Lincolnshire flint appears to differ in this way from Brandon flint. Such differences are also to be observed in the flints of different horizons in one and the same chalk-pit.

Some observers call those flints which, after fracture, tend to develop a bluish glaze "chalcedonic"; but there are nodules which superficially look like "flints" to be found in association with ordinary black flints in the chalk of the south of England, which are apparently true chalcedony throughout, nearly transparent and colourless, with a bluish cloud in the depths. These almost invariably are oblong nodules embedding a sponge, and form beautiful objects when cut and polished. Often they contain (even when in the chalk) small quantities of iron, which produce in the transparent chalcedonic substance striking patches of red and brown colour.

Cavities occur in chalk flints as in the agate of the geodes of igneous rock, and rock crystal, as well as botryoidal chalcedony, is often found lining the cavities of the flints as of the agate geodes. Occasionally crystals of iron sulphide occur in chalk flints. We require some definite classification and recognition of the varieties of chalk flint and their probable significance. The hardness fracture, density, and especially the elasticity of each *kind* of flint must be measured and stated.

(2) As to the *origin* and *formation* of flint, our knowledge seems to be very little further advanced than it was fifty years ago. The microscopic examination of thin sections of flint has not been applied to many varieties of flint, and, so far as I can ascertain, possible methods of staining thin sections and of applying light, heat, and chemical agents to the detection of structure and differentiation in the substance of thin sections of flint, examined with the microscope, have not been thoroughly and extensively used.

It appears to be held that the normal chalk-flint consists of extremely minute crystals of silica, cemented by opaline silica, and that the white cortex which every chalk-flint possesses is due to the removal of the opaline cementing colloid silica from the cortical region by solution. One would like to know more about this as the outcome of experiment. What is the solvent? Re-deposited flints in Pleistocene gravels are often opaque ("decomposed," it has been called) right through, and in some cases are pulverulent. How has this been brought about? Broken flints (flint implements) in Pleistocene gravels sometimes show a curious basket-work of white bands crossing and interlaced on a black ground. Is this white pattern a pre-existent structure developed by the action of a solvent? Can such a change be produced experimentally?

There is no general agreement as to the mode of origin of the flints in the chalk. It is clear from the existence of tabular flint in vertical and oblique fissures traversing great thicknesses of chalk that the flint was deposited in cavities formed after the solidification of the chalk. It is also probable that the silica deposited is the opaline or colloid silica of the spicules and shells of marine organisms mixed up with calcareous particles in the original chalk ooze, and dissolved out of it by percolating water containing some solvent—but what? What are the circumstances which have determined (1) the solution of the colloid silica of spicules, and (2) its deposition in the form of cavity-filling masses consisting of minute crystals cemented by colloid silica?

The cavities in which the nodular flints were formed were probably once filled by organic lumps and débris, but it is questionable whether the organic matter attracted the silica and determined its deposition (although we know this occurs in the silicification of tree-trunks in the sea), since flint is deposited freely in the tabular form in the upper chalk, in vertical fissures containing no organic residues. In what respects (one would like to inquire) is the mode of deposition of chalk-flint similar to, and different from, that of chert on the one hand and of geode-agate on the other? The solubility of the colloid silica of organic skeletons requires investigation. The silica deposited as agate in trap-rocks had probably a different origin from that of flint.

(3) Apart from these questions as to the intimate structure of flint, its varieties, and its origin in the chalk, there are certain more direct and simple physical investigations of flint which are necessary, and would help us in distinguishing varieties of flint, and perhaps throw light on other questions. They certainly would render it possible for archæologists to speak of facts and not merely make guesses as to the causes of the fracturing of flints found in Pleistocene, Pliocene, and other Tertiary deposits.

The most important of these inquiries are (1) as to the *porosity* of flint, and (2) as to the *fracture* of flint by blows, by pressure, by heat, and by cold. The two inquiries are closely related. It is well known that an agate geode is porous, and will absorb a large quantity of water containing colouring matters in solution. Our chalk flints are also highly porous and absorbent of water. But, so far as I can ascertain, this property has never been investigated quantitatively. It should be determined experimentally in the case of normal black flint from the chalk (and in varieties of it and in allied bodies). We require to know—

(1) What is the difference in the specific gravity of flint fresh from the chalk, and of carefully dried flint, from which all free water has been removed by non-destructive methods of desiccation?

(2) What is the maximum amount of water which such a specimen of dried flint can be made to absorb? We could thus get the coefficient of absorption of water by flint at various pressures and temperatures, also of flint lying naturally in the chalk, as compared with flint when lying on the surface and under various other conditions.

(3) Other facts as to this porosity could be accurately determined, as, for instance, in what way it is related to structure. Coloured substances might be forced into the pores, as also chemical solvents, and microscopic examination of thin sections made with very high powers.

The investigation of *fracture* is closely related to the foregoing. The most familiar and certain cause of the fracture of flint is a blow with a hammer wielded by a man. Many archæologists are (I have found) not aware that according to the character of the blow given flint may be broken with a practically flat surface of fracture, or, on the other hand, with what is called "a conchoidal fracture." The flint-knappers of Brandon break the large masses of flint removed from the chalk into blocks of convenient size by heavy blows given with what they call "a quartering hammer." The surfaces of fracture so obtained are not "conchoidal." A heavy blow in a direction perpendicular to the surface gives this plane fracture. The lighter knapping hammer gives the kind of blow which produces a conchoidal fracture, and the flint workers can produce complete cones of flint at pleasure by giving the needful kind of blow.

The exact quantitative features of the weight, velocity, and direction of this blow must be determined experimentally, as also must those of the "quartering" or plane-fracture blow. Apparatus to determine these features could be devised. It would then be possible to investigate the exact measurable characters of the conchoidal fracture or "cone" or "dome" of percussion, and to compare it in different varieties of flint. It would be very important to determine whether "saturated wet flint" has the same fractural indices as "dry" flint—whether the one fractures with conchoidal form as easily as the other, &c., &c. Then we could arrive at an answer to the question, "What weight and velocity of blow were necessary to produce the fracture (whether conchoidal or plane) exhibited by a given piece of flint?" And so it would be possible to arrive at a certainty as to whether the fractures which give shape to some supposed human flint implements could have been produced by the inter-concussion of flint nodules driven by the waves of the sea.

But in this investigation the very important fact would be exactly and quantitatively determined that the vibration tending to set up a conchoidal fracture may produce a "flaw" when the blow causing it was not of sufficient power to cause an actual fracture, and the subsequent history of such "flaws" would be experimentally studied. I have found that one of the most certain ways of obtaining a fine "dome of percussion" in black chalk-flint is to strike a "*staccato*" blow with a light hammer. No fracture results, but subsequent "tapping" with a heavier hammer causes the flint to yield along the dome-like plane of "flaw" set up by the first blow.

The fracture of flint by blows due to other agents than man has been rarely observed. At a few points on the sea-coast large flint pebbles may be picked up with one, or even six or seven, irregularly placed conchoidal fractures of the size of a haricot bean at most. Observations of the fracture of flint by torrents or by heavy wave-action are not forthcoming. The delicate pitting and granulation of the surface of flint-pebbles on the seashore is due to the action of the sea-waves causing the pebbles to knock against one another, and is a very different thing from large and uniformly "directed" fracture.

Leaving for a moment the question of the fracture of flint under graduated pressure, we must cite the action of cold and of heat in fracturing flint as demanding careful and quantitative investigation. There is no doubt that in this country the greatest "breaker of flint" is frost. In the Egyptian desert a chert-like substance allied to flint is constantly fractured by the heat of the sun. It is most important to determine whether "wet" and "dry" flint are equally subject to fracture by cold and also by heat. Has the water absorbed by porous flint any important part in its thermal fracture? The artificial fracturing of flint by the heat of camp-fires is well known as a mere fact. But the very curious structure of flint revealed by it has never been investigated.

I do not know whether anyone else has ever determined the simple fact experimentally that sudden exposure to cold will cause flint to fracture—to "fly," as the expression is in the case of glass. But last July Sir James Dewar kindly placed some large flakes of Brandon flint (prepared by the flint-knappers for breaking into gun-flints), which I brought to his laboratory, into liquid air in my presence. An extensive fracture of peculiar form, its edge having a deeply undulated margin like that of an oak-leaf, was the result. Obviously the whole subject of the fracture of flint by cold and by heat requires experimental investigation, and must yield results of great importance. I am not in a position to carry out this investigation myself, nor have I the necessary training in such determinations. My hope is that some physicist may be attracted by the subject.

An important point which I should wish to determine as bearing on the appearances presented by broken flints in Tertiary strata and gravels is whether frost can, in any circumstances, produce a *conchoidal* fracture in flint. It seems to me not improbable that a flint may by natural (*i.e.* non-human) blows, or a single blow—insufficient to break it—have acquired conchoidal "flaws," or a single conchoidal flaw, which would be developed as a conchoidal "fracture" when the flint was caused to break by sudden frost. We do not even know whether "suddenness" is an element in the causation by lowered temperature of the fracture of flint. The flints on the surface of chalk downs and in many of our later gravels are one and all broken into irregular angular fragments. This is probably correctly attributed to frost, but it would be possible to gain more precise information as to the conditions and determining causes of that fracture. The exact temperature at which, under varying conditions, fracture occurs and the possible extent and form of frost-fractures could be determined. The same is true with regard to the fracture of flint by heat.

The investigation of pressure as causing fracture of flint can be accurately investigated. What kind of fractures can be produced by pressure? And what kind of pressure can produce fracture? We have been asked to accept the statement that the pressure of sandy strata overlying flints can fracture them. By many this is considered an impossibility. We are then told of some mysterious kind of rolling or sliding pressure as producing such effects. Its action should be experimentally demonstrated.

Lastly, in regard to fracture, there seems to be a possibility that vibrations produced by very slight blows may, in special circumstances (such as great cold or heat or dryness), start large fractures in an elastic body like flint. The possibility requires experimental investigation.

There remain yet to be mentioned some other matters for experimental investigation in regard to flints. The acquirement of green, of yellow, brown, and rich red, as well as of black *coloration*, both deeply and superficially, by flint nodules and pebbles when deposited in Tertiary strata is one of these. This subject is part of the general subject of the porosity of flint. It has an important bearing on the study of the flint implements found in gravels. Of more peculiar importance is the classification of the different states of polish which broken flints, whether implements or not, present in different gravels. And with this has to be associated the study of the chemical and molecular changes of the surface of broken flints, and their curious laminar and vermicular sculpturing. Further, the deposition upon those broken surfaces of chemical material requires precise investigation. The "glaze" of the fragments of bone and teeth in the bone-bed at the base of the Red Crag is usually attributed to the deposition on them of phosphate of lime.

It is not certain that this is a correct conclusion. Is the peculiar glaze of most of the broken flints from that deposit due to chemical action, or are all the glazes supposed to be present on broken flints really only different degrees of sand polish effected by wind or by water?

The wonderful flints found in small number in the Savernake gravel, which look as though they had just received a wet coat of spirit varnish, have never yet been satisfactorily dealt with. Some geologists have supposed that they owe their appearance to a chemical glaze deposited on them. But microscopical sections are absolutely contradictory of that view. Their wonderfully brilliant surface is almost certainly a water-made sand-polish. But one would like to see such polishing of an irregular surface of flint produced experimentally. And it would be important to know what were the conditions at work at Savernake to produce this polish on small Acheulian flint implements, as well as on unbroken flint pebbles of large size, and upon one and not all the surfaces of irregular fragments.

A detailed knowledge of the causes of colour and colour patterns, and of the glazing and polishing of flint implements, would enable prehistorians to give a more complete account of the historical vicissitudes of this and that implement than is at present possible. The most urgently needed of the investigations above suggested appears to me to be the experimental and quantitative determination of the causes and conditions of the different kinds of fracture of which flint is susceptible.

E. RAY LANKESTER.

November 9.